TECHNICAL NOTES

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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PRESSURE-DISTRIBUTION MEASUREMENTS ON A RECTANGULAR WING WITH A PARTIAL-SPAN SPLIT FLAP IN CURVED FLIGHT

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Pressure-distribution tests were made on the 32-foot whirling arm of the Daniel Guggenheim Airship Institute of a rectangular wing of N.A.C.A. 23012 section to determine the rolling and the yawing moment due to an angular velocity in yaw. The model was tested at 0° and 5° pitch; 0°, $\pm5^\circ$, and $\pm10^\circ$ yaw; and with no flap and with split flaps 25, 50, and 75 percent of the wing span and deflected 60°.

The results are given in the form of span load distributions and as calculated moment coefficients. The experimental values of rolling- and yawing-moment coefficients were in fairly close agreement with theory.

INTRODUCTION

Investigations have been reported in references 1 and 2 of the pressure distribution over a Clark Y tapered wing model with full-span and with partial-span flaps. The tests were made with the 32-foot whirling arm of the Airship Institute. The results were presented as span load distributions and as rolling- and yawing-moment coefficients for different conditions of pitch and yaw. The work was carried out with the financial assistance of the National Advisory Committee for Aeronautics.

With the same type of equipment, similar tests were made with an N.A.C.A. 23012 rectangular wing model with partial-span split flaps. The results are presented in the present paper.

APPARATUS AND TESTS

A complete description of the test set-up and the test procedure can be found in reference 1.

The rectangular wing model of N.A.C.A. 23012 section for these tests was all metal and similar in construction to the tapered wing model described in reference 1. Figure 1 is a sketch of the wing showing its principal dimensions and the chords along which the pressure orifices were located.

The flaps for these tests were made in sections, each being 25 percent of the semispan. These quarter sections were merely added to or removed from the model to produce the desired flap lengths, 25 percent, 50 percent, or 75 percent of the span. They were made of 1/16-inch steel plate with pressure orifices on both the upper and the lower surfaces of the flap.

The model was tested at 0° and 5° pitch; 0°, $\pm 5^\circ$, and $\pm 10^\circ$ yaw; and with the 25-percent, the 50-percent, and the 75-percent split flap deflected 60°. Positive yaw denotes moving the outer edge of the wing forward. For all the tests, the ratio of the span to the turning radius was equal to 0.133.

TEST RESULTS AND DISCUSSION

Typical diagrams of the pressure distributions over the upper and the lower surfaces of the airfoil for different flap lengths are given in figure 2 as ratios of the static pressure p to the dynamic pressure q_o of the true flight velocity at the center of the wing.

The pressure diagrams for the various wing positions were graphically integrated and, from the data thus obtained, nondimensional coefficients were computed for the wing as a whole.

The local normal-force coefficient c_n and the local chord-force coefficient c_c for 5° pitch and 0°, $\pm 5^\circ$, and $\pm 10^\circ$ yaw are plotted in the load grading curves of figures 3 and 4, where:

$$c_n = \frac{n}{q_o \ c_{local}}$$

$$c_c = \frac{c}{q_o \ c_{local}}$$

In table I are given the values of the rolling-moment coefficient C_l and the yawing-moment coefficient C_n obtained by graphical integration:

$$\int_{-b/2}^{b/2} F\ y\ dy$$

where

$$C_l = \frac{L}{q_o\ bS}$$

$$C_n = \frac{N}{q_o\ bS}$$

and n is normal force per unit span.

c, longitudinal force per unit span.

c_{local}, chord of airfoil section.

y, distance along span.

b, wing span.

L, rolling moment.

N, yawing moment.

S, total wing area.

Figure 5 shows the effect of the angle of yaw on the rolling- and the yawing-moment coefficients for the model at 5° pitch with 0, 25-, 50-, and 75-percent span flaps.

The theoretical rolling moment is given by

$$L = C_{l_r} \frac{rb}{2V}\ qSb$$

where r is turning speed in radians per second.

V, flight velocity.

q, dynamic pressure.

The value of C_{l_r}, the rolling-moment coefficient, was obtained from figure 11 of reference 3 for a wing having a taper ratio of 1.00 and an aspect ratio of 6. The span b was 1.372 meters and the wing area S was 0.2958 square meter. For the N.A.C.A. 23012 wing section without flap, the angle for zero lift was assumed to be -1.2° (reference 4). For the condition of 0° pitch, this value gives $\alpha = 1.2^\circ$; for the 5° pitch setting, $\alpha = 6.2^\circ$. The flap of 25-percent chord deflected 60° was assumed to be equivalent to an increase $\Delta\alpha$ of 14°. (See reference 2.)

The theoretical yawing moment N is defined by

$$N = C_{n_r} \frac{rb}{2V} qSb + \Delta C_{n_r} \frac{rb}{2V} qSb$$

where C_{n_r} is the yawing-moment coefficient obtained from figure 13 of reference 3 for a wing having a taper ratio of 1.00 and an aspect ratio of 6.

ΔC_{n_r}, yawing-moment coefficient due to the profile drag obtained from figure 14 of reference 3 for a wing without flap having a taper ratio of 1.00 and a profile-drag coefficient $C_{D_o} = 0.010$.

Figure 6 gives a comparison between the experimental and the theoretical rolling- and yawing-moment coefficients for the 0° and 5° pitch and the 0° yaw positions of the model. The theoretical coefficients were computed according to reference 3.

CONCLUSIONS

1. The experimental rolling-moment and yawing-moment coefficients are in fairly close agreement with the theoretical ones.

2. The rolling-moment coefficients are little affected by the angle of yaw within the range tested of $\pm 10^\circ$.

3. Small variations in the normal-force distribution, especially at the tips of the wing, have little effect on the resulting rolling-moment coefficient.

4. The yawing-moment coefficients exhibit considerable change due to the angle of yaw, especially on the model with a partial-span flap. The coefficient increases as the wing model is yawed in a positive direction and decreases as the wing model is yawed in the negative direction. The yawing-moment coefficient for -10° yaw reached a slight negative value for the 25-percent and the 50-percent span flaps, the trend of the curves indicating larger negative coefficients for yaw angles beyond -10°.

5. The negative yawing moments for 25-percent and 50-percent span flaps at -10° yaw angle are brought about, as is apparent from pressure-distribution curves, by the somewhat higher pressure on the forward side of the flap near its tip on the inner portion of the span as compared with the outer portion, accompanied by a somewhat higher negative pressure at the rear of the flap on the inner portion of the span as against the outer portion.

Daniel Guggenheim Airship Institute,

Akron, Ohio, October 5, 1939.

REFERENCES

1. Troller, Th., and Rokus, F.: Pressure-Distribution Measurements on a Tapered Wing with a Full-Span Split Flap in Curved Flight. T.N. No. 683, N.A.C.A., 1939.

2. Troller, Th., and Rokus, F.: Pressure-Distribution Measurements on a Tapered Wing with a Partial-Span Split Flap in Curved Flight. T.N. No. 735, N.A.C.A., 1939.

3. Pearson, Henry A., and Jones, Robert T.: Theoretical Stability and Control Characteristics of Wings with Various Amounts of Taper and Twist. T.R. No. 635, N.A.C.A., 1938.

4. Jacobs, Eastman N., and Clay, William C.: Characteristics of the N.A.C.A. 23012 Airfoil from Tests in the Full-Scale and Variable-Density Tunnels. T.R. No. 530, N.A.C.A., 1935.

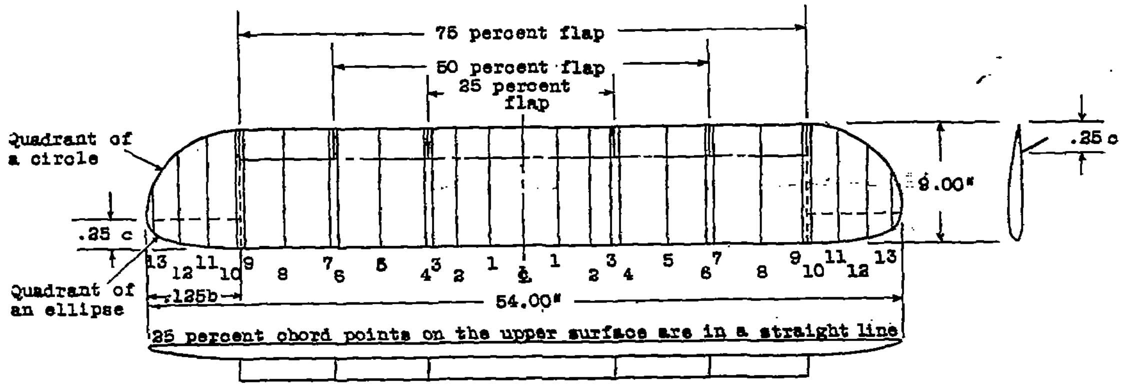
TABLE I

Values of C_l

Angle of yaw (deg.)	0° pitch Extent of flap (percent span)				5° pitch Extent of flap (percent span)			
	0	25	50	75	0	25	50	75
10	0.0028	0.0029	0.0067	0.0169	0.0056	0.0073	0.0132	0.0234
5	.0020	.0028	.0070	.0167	.0065	.0078	.0143	.0216
0	.0024	.0032	.0071	.0169	.0070	.0086	.0132	.0215
-5	.0022	.0035	.0079	.0183	.0070	.0095	.0152	.0226
-10	.0021	.0046	.0090	.0180	.0065	.0106	.0167	.0223

Values of C_n

Angle of yaw (deg.)	0° pitch Extent of flap (percent span)				5° pitch Extent of flap (percent span)			
	0	25	50	75	0	25	50	75
10	0.00062	.00079	.00158	.00451	.00129	.00172	.00288	.00536
5	.00034	.00057	.00118	.00220	.00101	.00113	.00181	.00369
0	.00034	.00068	.00102	--	.00079	.00119	.00164	.00304
-5	.00017	.00006	.00023	.00057	.00068	.00091	.00119	.00169
-10	.00006	-.00022	-.00034	.00011	0	-.00034	-.00034	.00034



Chord	Distance from center of span, in.	Chord	Distance from center of span, in.	Chord	Distance from center of span, in.
1	2.50	5	10.25	10	20.50
2	4.75	6	13.25	11	22.50
3	6.50	7	13.75	12	24.44
4	7.00	8	17.00	13	26.30
		9	20.00		

Figure 1.- Sketch of N.A.C.A. 23012 rectangular wing showing location of pressure orifice chords.

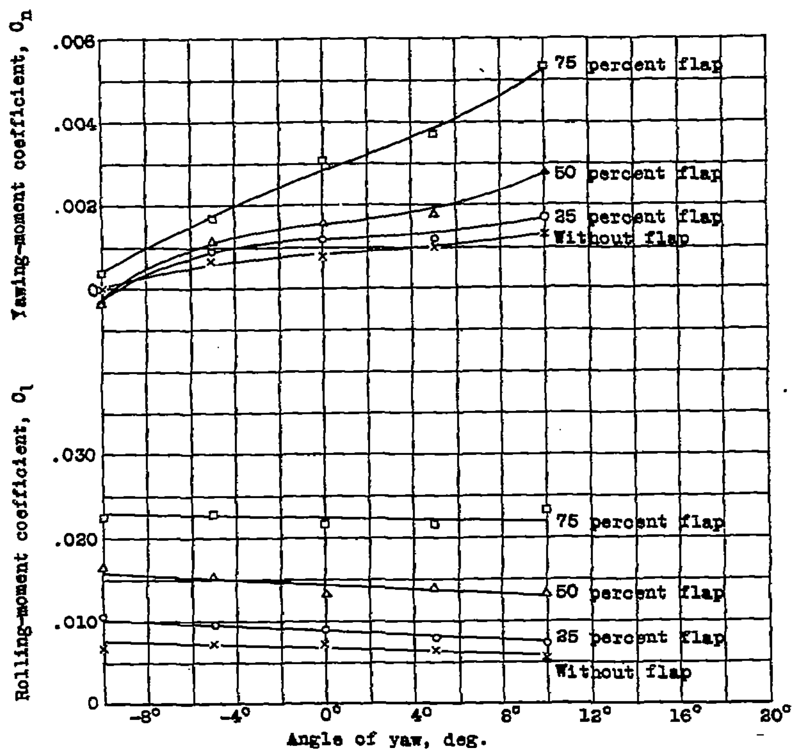
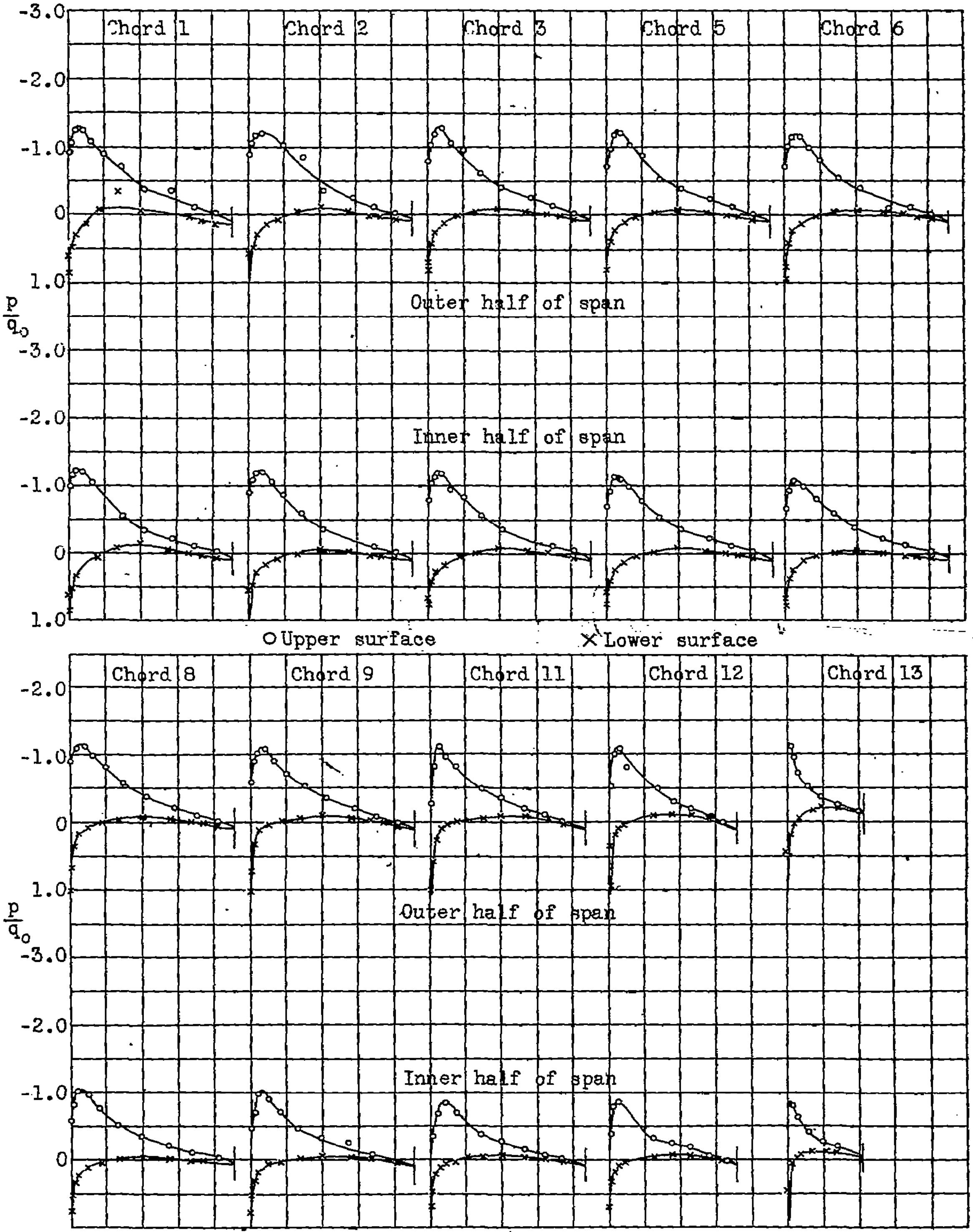
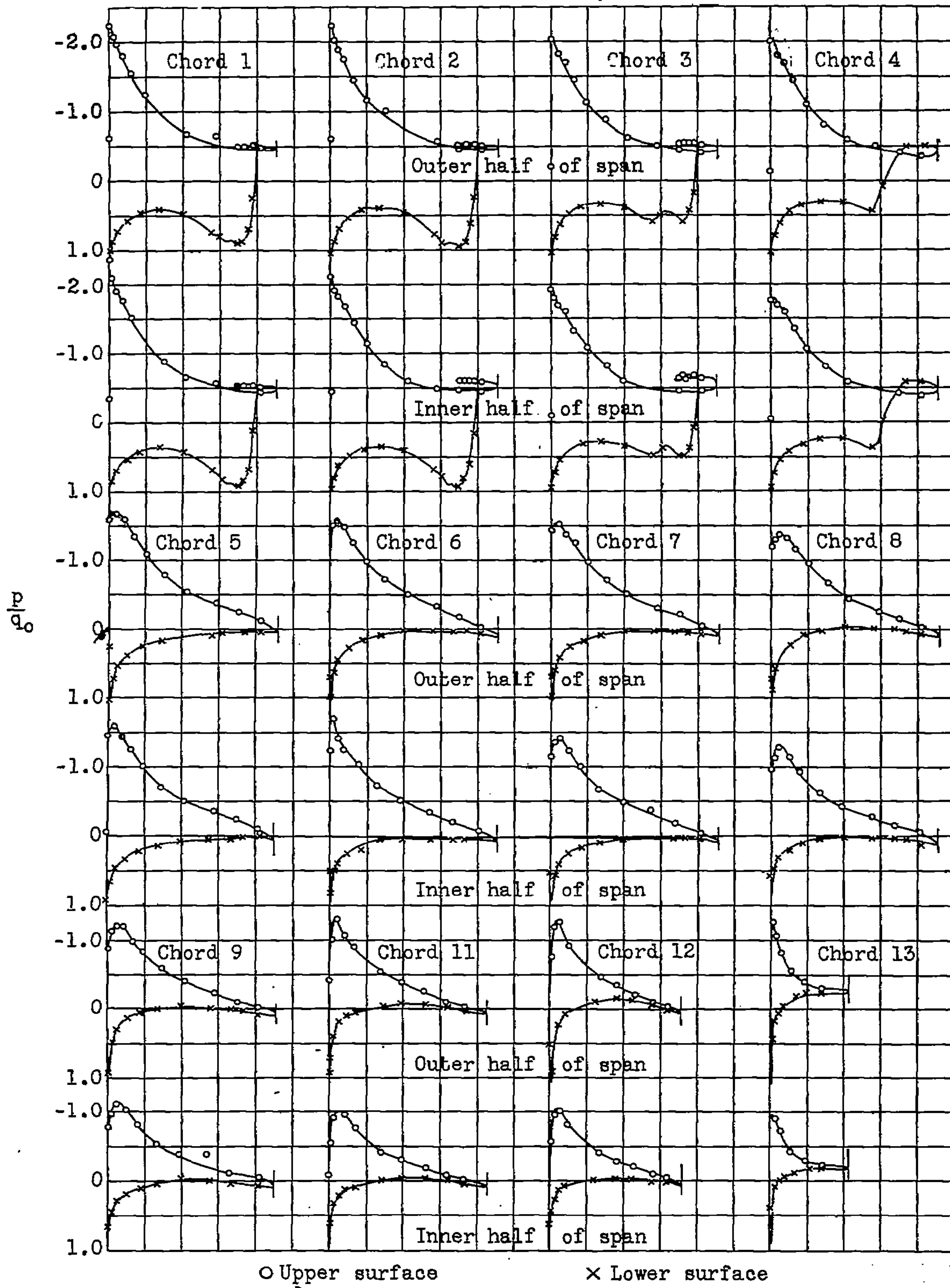


Figure 5.- Effect of yaw angle on the rolling-moment and yawing-moment coefficients.



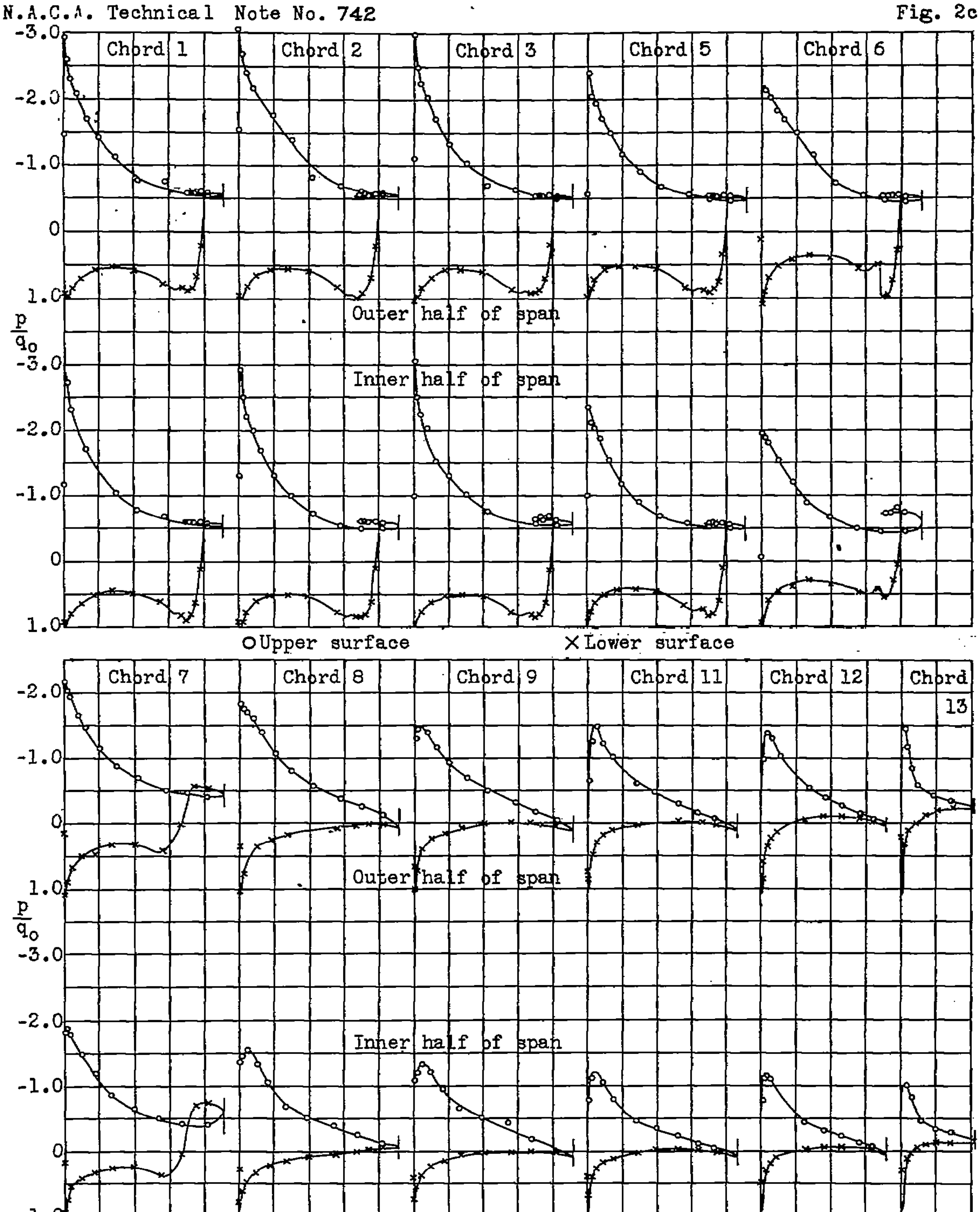
(a) Wing without flap

Figures 2a to d.- Pressure-distribution curves for model at 5° pitch and 0° yaw.



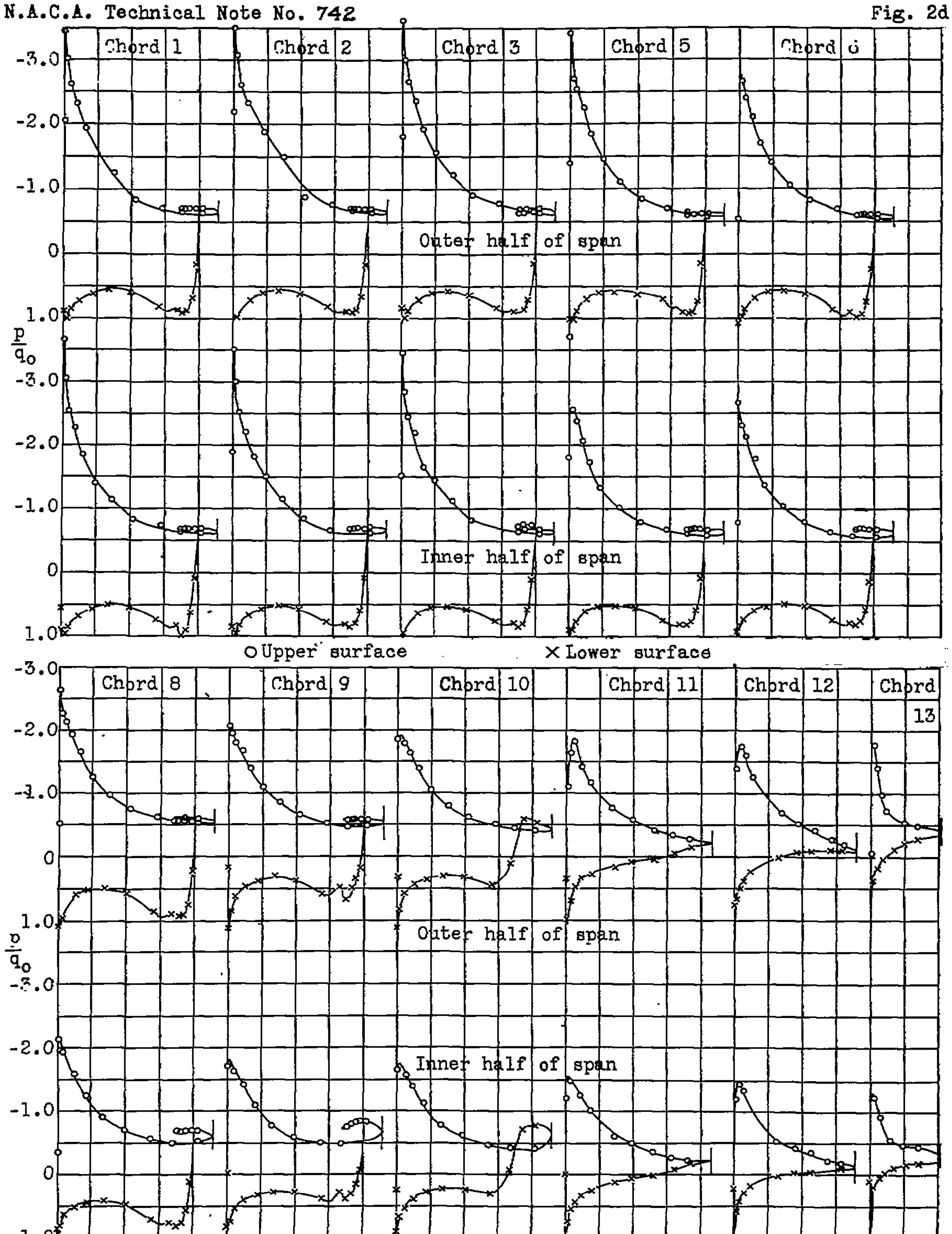
(b) Wing with a 25 percent span split flap deflected 60°

Figure 2.- Continued.



(c) Wing with a 50 percent span split flap deflected 60°

Figure 2.- Continued.



(d) Wing with a 75 percent span split flap deflected 60°

Figure 2.- Concluded.

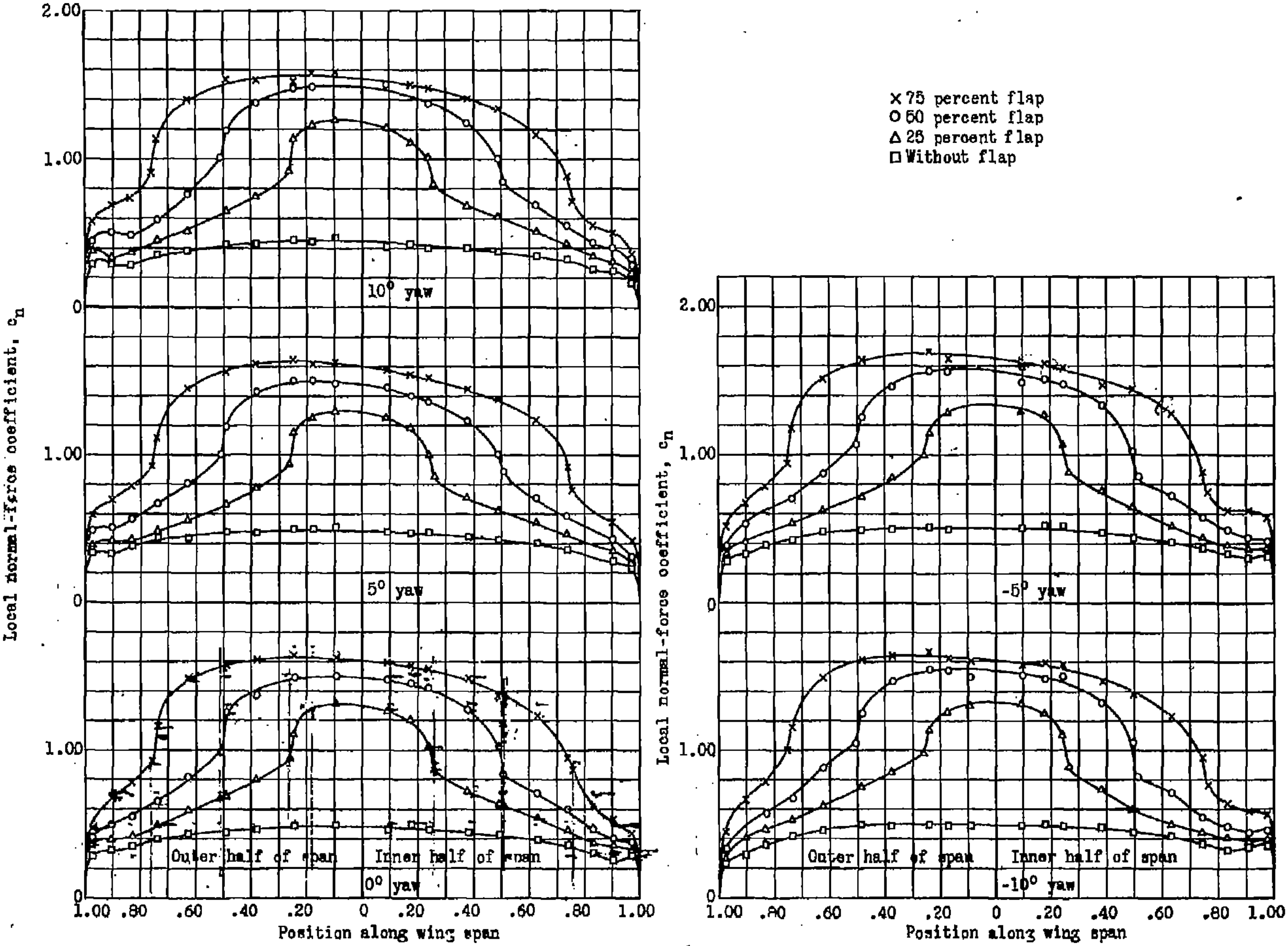


Figure 3.- Spanwise distribution of normal-force coefficient for 5° pitch and various yaw angles.

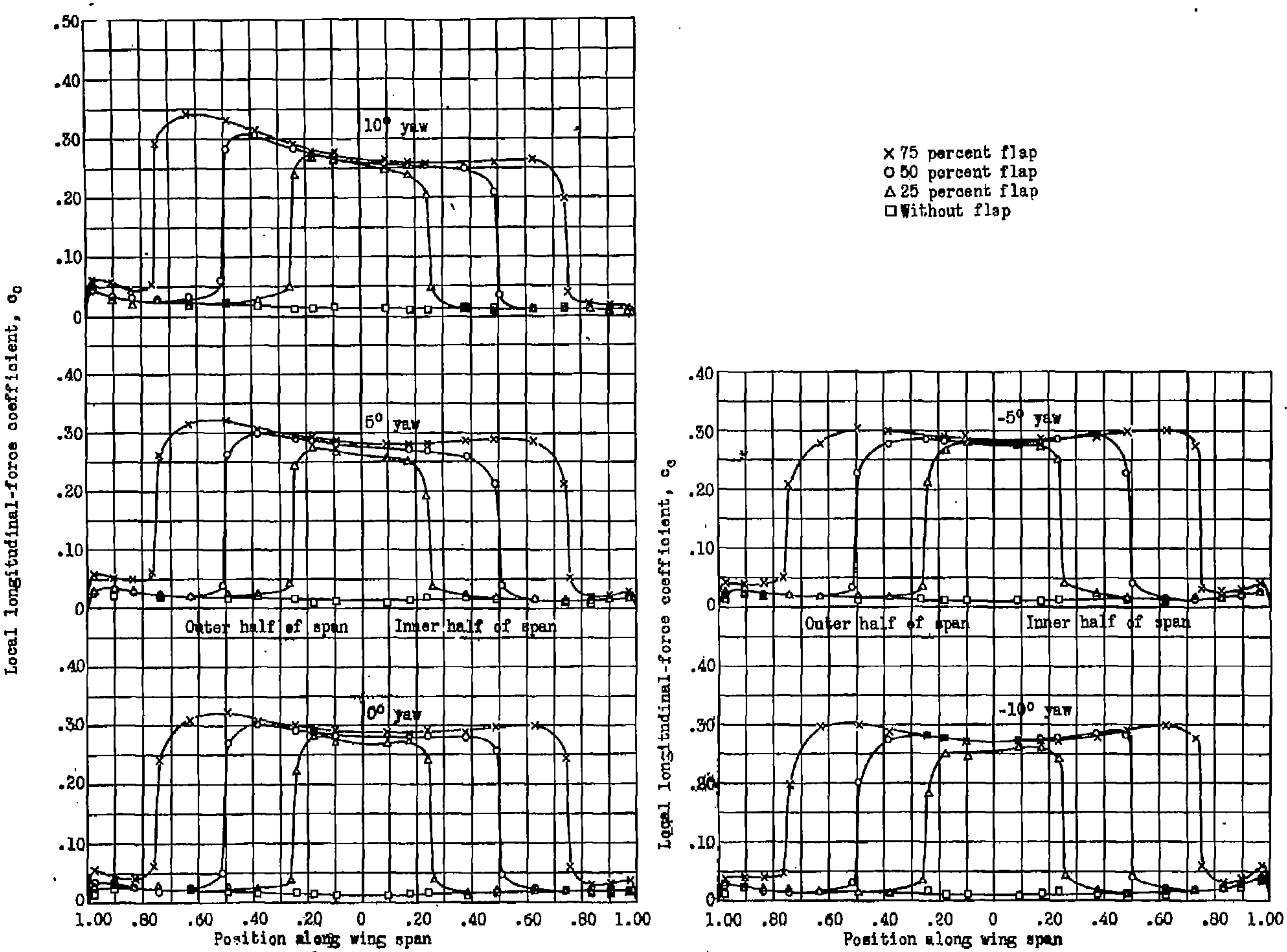


Figure 4.- Spanwise distribution of longitudinal-force coefficient for 5° pitch and various yaw angles.

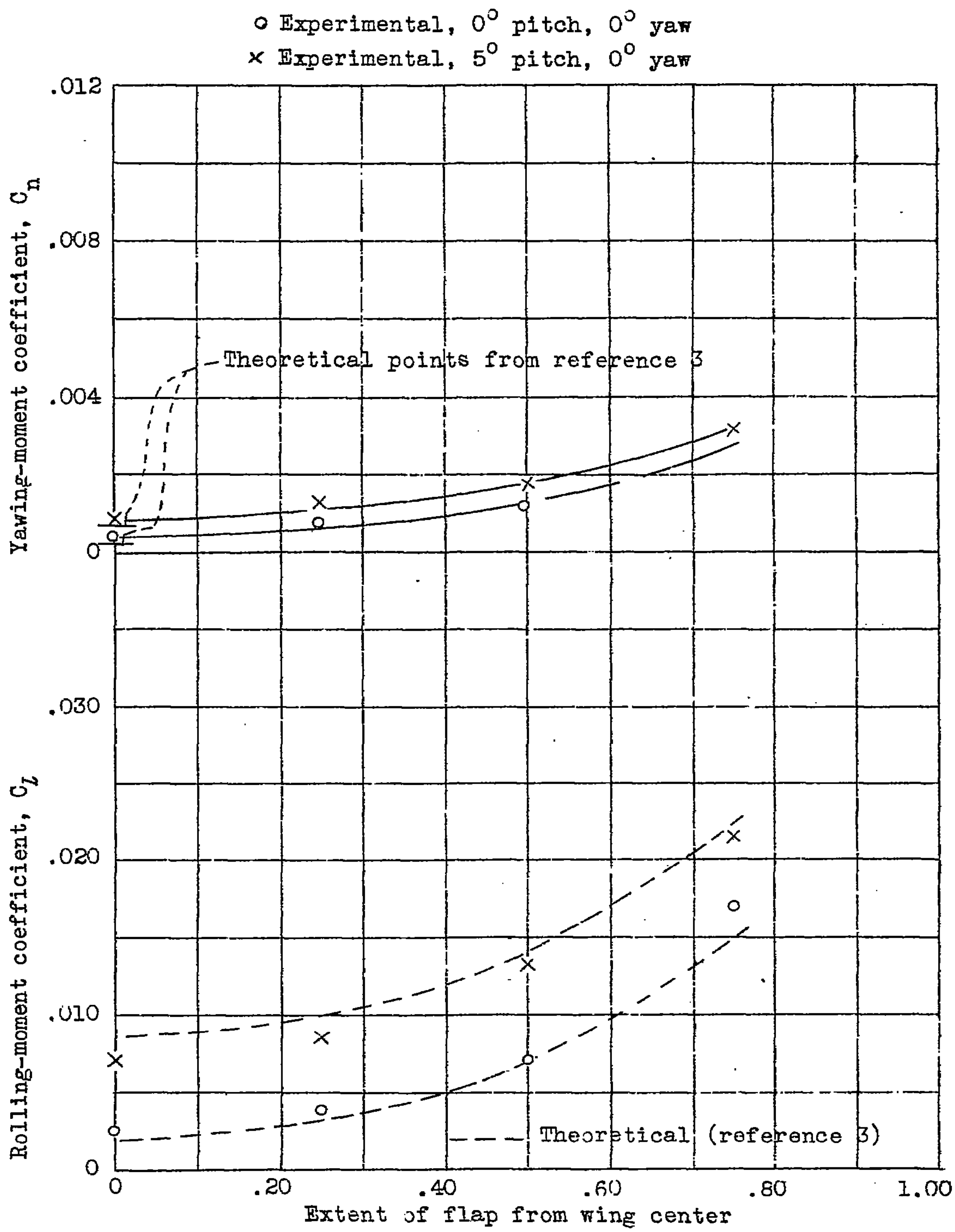


Figure 6.- Comparison of theoretical and experimental rolling-moment and yawing-moment coefficients.